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Effect of Maize Varieties on some Biological Aspects of the Lesser Grain Borer *Rhyzopertha dominica* (Bostrichidae: Coleoptera).

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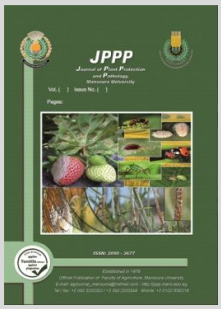

ABSTRACT

The experiments were conducted at the laboratory of Entomology belonging to the Economic Entomology Department, Faculty of agriculture, Mansoura University. The developmental period, progeny weight loss, and susceptibility of maize varieties to *Rhyzopertha dominica* (Fab.) (Bostrichidae: Coleoptera) was determined through the free-choice and non-choice tests among maize varieties. In addition, the chemical composition of the tested varieties was estimated in relation to variety susceptibilities to this insect. The longest development period (29.4 ± 0.04 days), the lowest progeny production in the first and second generations (19.4 ± 1.21 and 33.2 ± 0.58 individuals), and the lowest weight loss of grains in the two generations (0.33 ± 0.03 and 0.45 ± 0.02 grams) by *R. dominica* was occurred on the Single cross 132 (S.C. 132) variety. Whereas The Single Cross 178 (S.C.178) exhibited the lowest attractiveness to *R. dominica* This low attractiveness of the single Cross 178 (S.C.178) is due to the low amounts of protein, fiber, total carbohydrates, calcium, zinc, iron ash, and magnesium.

Keywords: *Rhyzopertha dominica*; Biological aspects; Maize varieties; Susceptibility; Free-Choice Test

INTRODUCTION

Maize crop is considered one of the most important crops in Egypt and worldwide because of its economical and nutritional importance both to human and animals. In addition, it is considered a raw material for the alcohol industry (Ezzeldin *et al*., 2009). The total area of maize in Egypt was about 2195 thousand feddans, which constitutes about 4.28% of the total area of grain crops (Youssef, 2004). It is used as animal feed, in the form of concentrated grains.

The lesser grain borer, *Rhyzopertha dominica* (Fab.) (Bostrichidae: Coleoptera) is one of the most serious pests that highly infest stored grains (Edde *et al.*, 2005; Edde, 2012; Ajaykumara *et al*., 2018; Hendrival and Aryani, 2019). The larvae and adults of *R. dominica* feed on the grains. The feeding not only causes quantitative damage to the grains, but also facilitates the infestation of these grains with other secondary pests and fungi, which finally affect the quality of these grains (Arthur *et al.*, 2012 and Locatelli *et al.*, 2019). In addition to the severity of the infestation in the grains, which may result in the presence of holes in the grains, only a thin cover of the grain remains (Vardeman *et al.*, 2007).

More than one individual can grow and complete their immature development inside each grain that making infestation more difficult to detect in early phases resulting in difficulties in make a control decision (Chanbang *et al.*, 2008; Chougourou *et al.,* 2013).

The maize variety had high influence on some biological features of *R. dominica* (Singh and Pandey,1977; Locatelli *et. al.,* 2019). In addition, the chemical composition analysis has been used to determine the more susceptible variety grains to *R. dominica*. The chemical composition of grains plays a major role in infestation rates (Pandey, 1977; El-Halfawy and Hassan, 1978; Towes *et al*., 2000; Chougourou *et al*., 2013). The high percentage of carbohydrates, protein, fibers, and moisture on maize led to high infestation percentages and made the variety more susceptible to infestation (Astuti *et al.,* 2013 and Saad *et. al.* 2018).

Therefore, the present work aimed to study the effect of maize varieties on some biological aspects of the lesser grain borer *R. dominica.* under laboratory conditions. In addition, the chemical composition analysis was also used to determine the more susceptible variety.

MATERIALS AND METHODS

The present study was carried out in the laboratory of Entomology belonging to the Economic Entomology Department, Faculty of Agriculture, Mansoura University.

Insect culture

On wheat grains, the grains were sterilized at -18 ºC for 48 hours to eradicate any visible or concealed insects and mite infestations. To equilibrium the moisture content of these grains, they were conditioned for at least a week in an incubator at 35±1 ºC and 60±5% R.H. These grains were then used to mass raise the insect in glass jars with a capacity of 2 liters. The insects used for grain infestations were received from the Agricultural Research Center in Sakha, Kafr El-Sheikh. The culture was maintained under 35±1 ºC and 65±5% R.H in the laboratory. The adults were collected from the culture to use in the current experiments.

Effect of maize varieties on some biological aspects of *R. dominica*

A. Non-choice test

This experiment was conducted to determine the developmental period, the progeny production of the first and second generations and the weight loss in grains inboth generations by *R. dominica* on five maize varieties of [Single cross 178 (S.C. 178), Single cross 10 (S. C. 10), Single cross 132 (S.C.132), Single cross 173 (S.C. 173), and Three ways

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cross324 (T.W.C.324)]. Ten grain grams from each variety were exposed to ten pairs of the lesser grain borer (2-3 weeks old) in a Petri dish (9 cm diameter). Each variety replicated five times. These insects were allowed to mate and lay eggs under 35 1 C and 655.0% RH and were observed daily. Once the eggs were laid, they were removed using a 10-mesh sieve. The grains were observed daily in order to find out the developmental period from the egg to emergence of the adults. After 30 days, the grains were weighed to estimate the weight loss resulting from the progeny of the first generation, as well as after 60 days, the progeny of the second generation were counted and the weight loss due to this generation was also counted. The susceptibility index was estimated using the Dobie equation (Dobie and Kilminster, 1977) as follows:

$$\text{Susceptibility index} = \frac{\text{Natural Log (F)}}{\text{D}} \; x\,100$$

where F is the number of first-generation progeny; D is the mean developmental period for *R. dominica*.

B. Free choice test

This experiment was conducted to determine the attractiveness of different maize varieties to *R. dominica*. Five grams of each maize variety were placed in a Petri dish (9 cm in diameter). These dishes were placed in a plastic box (45 cm in length, 20 cm in width, and 15 cm in height). 50 pairs of *R. dominica* adults were released in the middle of the box, maintained in the dark, and kept at 35±1°C 65±5 RH%.). Then, the insects harbored each dish (i.e. variety) were counted after certain periods of 24, 48 and 72 hours. The dishes in the plastic box were rotated after each observation to avoid any effect for direction. After 30 days, the progeny produced on each variety was counted and the grain weight to find out the weight loss resulting from infestation in each variety was estimated.

Determination the susceptibility of maize varieties to infestation by *R. dominica*.

- To determine the more susceptible variety to infestation by *R. dominica*, chemical composition analysis of each maize variety was performed as follows: Determination of Moisture Content was according to method of Marwaha (2010).
- Determination of Ash Content, Crude Fiber and Crude Protein was according to method of McCleary *et al.* (2013). Determination of Total carbohydrates was According to William (2000).
- Determination of minerals was according to Peters *et al.* (2009) and Kumpulainen *et al.* (1983).

Statistical analysis

Data for all experiments were analyzed using One-way ANOVA and means were separated using Duncan's Multiple Range Test. All analyses were done using Costat Version 6.45 (CoHort Software) (Stern, 1991).

RESULTS AND DISCUSSION

Statistical analysis showed a significant effect of five maize varieties on some biological aspects of the lesser grain borer *R. dominica*. The shortest development period of *R. dominica* was noticed on the single cross 10 (S.C.10) followed by the single cross 173 (S.C.173) and the single cross (S.C.132) (Table 1). Meanwhile, the longest developmental period for *R. dominica* was recorded on the single cross 178 (S.C.178) followed by the three ways cross (T.W.C.324).

The lowest progeny of the first generation (F1) was recorded on S.C.132 variety followed by T.W.C 324 and S.C.178 varieties. Meanwhile, the highest progeny of the first generation of *R. dominica* was recorded on S.C.10 variety. The lowest progeny of the second generation (F2) was determined on (S.C.132 variety followed by T.W.C 324 and S.C.178 varieties. Meanwhile, the highest progeny of the second generation for *R. dominica* was recorded on S.C.10 variety. Statistical analysis showed that there were significant differences between progeny production either in the first or second generation among maize varieties (Table 1).

Statistical analysis revealed that there were significant differences between maize varieties in the grain weight losses by F1 and F2 progenies of *R. dominica* (Table 1) The lowest weight loss by the first- and second-generation progenies was recorded on T.W.C.324, and S.C.132 varieties, respectively, whereas the highest weight loss by the first- and second-generation progenies of *R. dominica* was recorded on S.C.10 variety.

Statistical analysis revealed that there were significant differences between susceptibility index of *R. dominica* on various maize varieties (Table 1). The lowest susceptibility index of *R. dominica* was reported on (S.C.178, whereas the highest susceptibility index was recorded on S.C.10 variety.

Table 1. The biological aspects (±SE) of the lesser grain borer *R. dominica* that reared at 35 ± 1 C and 65.0 ± 5.0 R.H.%

Varieties Biological Aspects	Single cross 178 S.C. 178	Single cross 10 S. C. 10	Single cross 132 S.C.132	Single cross 173 S.C. 173	Three ways cross 324 T.W.C.324
Developmental period (days)	31.8 ± 1.62 a	26.4 ± 0.51c	29.4 ± 0.04 ab	28.2 ± 0.20 bc	30.2 ± 0.37 ab
No. of Progeny F1	20.8 ± 1.28 b	31.2 ± 1.24 a	19.4 ± 1.21 b	22.2 ± 0.86 b	19.8 ± 0.73 b
No. of Progeny F2	35.8± 0.86 c	48.8 ± 2.27a	33.2 ± 0.58 c	39.6 ± 0.68 b	34.2 ± 0.86 c
Weight Loss F1 (grams)	0.37 ± 0.02 bc	0.64 ± 0.03 a	0.33 ± 0.03 c	0.434 ± 0.02 b	0.3± 0.01 c
Weight Loss F2 (grams)	0.65 ± 0.02 b	0.78 ± 0.04 a	0.45 ± 0.02 c	0.61 ± 0.02 b	0.46 ± 0.01 c
Susceptibility Index	9.64 ± 0.60 b	13.05 ± 0.38 a	10.07 ± 0.29 b	10.98 ± 0.14 b	9.88 ± 0.17 b

Means followed by the different letters in a row are significantly different at 5% probability level (Duncan's Multiple Range Test).

In this study, the grain weight was affected by *R. dominica* infestation., The S.C. 178 variety was the least infected among the other varieties, and the sensitivity coefficient was low, which gives evidence that it is more resistant to infestation by the Lesser grain borer *R. dominica*. In contrast, the S.C.10 variety lost a trace weight compared with the rest of the varieties, and the susceptible index was the highest. This is consistent with the results of Salma and Youssef (2004), where the S.C.10 variety was the most sensitive to insect infestation and the studied varieties could be arranged based on the susceptibility as follow S.C.10 > S.C.173 > S.C.132 > S.C.173 > T.W.C.324. The results of chemical analysis of the examined maize varieties came in the same trend and supported the results gained from the susceptibility studies. The same is obtained by Towes *et al*. (2000) .

The consumption of grains by *R. dominica* have evaluated in several studies (Bashir, 2002; Kurdikeri *et al.*,

1983) under laboratory conditions, but the loss estimation varied among authors, and this may be due to the differences between study conditions, varieties, or/and the strains of *R. dominica.*

The weight loss percentage by the first-generation progeny was the greatest in S.C.10 variety and represented by 6.40 %, whereas it was the lowest in the T.W.C.324 variety and represented by 3%. By the second-generation progeny, it was greatest in the S.C.10 variety and presented by 7.78, whereas it was lowest in the S.C.324 variety and represented by 4.46%.

It was found that in the second-generation weight loss is not identical to the first-generation, where the rate is relatively lower according to the weight loss caused by one insect, and it is believed that this is because, in the second generation, there are a greater number of incomplete individuals present inside the grain, which partially compensates for the lost weight, but this cannot be To compensate for the qualitative loss of these grains.

In the free-choice test, the variety S.C178 attracted the most insects (16.4 ± 0.75 individuals) after 24 and 48 hr., while T.W.C 324 variety had the fewest number of *R. dominica* (7.4 ± 0.40 individuals). WhileS.C173 variety had the highest number of insects, and S.C132 variety had the lowest number of insects after 72 hr,. In addition, statistical analysis revealed that there were significant differences between maize varieties in their attractiveness during the different observation periods (Table 2).

It should be stated that both the chemical and physical characteristics of grains have a strong impact on *R. dominica's* development rate and grain infestation capacity (Kavallieratos *et al*., 2010).

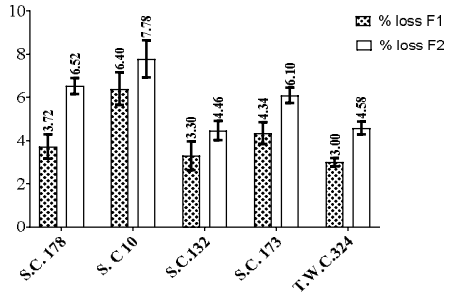

Fig. 1. The weight loss percentage of whole grain of maize of different varieties **caused by *R. dominica*.**

According to (singh and pendey, 1977; Youssef, 2004), phenolic content of maize grain was significantly and negatively correlated with resistance to *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae). There was also proof that the thought siliceous hull of paddy inhibited the larval growth of *Tribolium castaneum* and *Trogoderma granarium*.

Hull morphology was thus regarded as a shady source of resistance because its efficacy varied with insect species., the hardness characteristics of wheat will have a significant impact on the attack of *Sitophilus oryzae* (Nadeem *et al*., 2011).

Table 2. Mean number ± SE of *R. dominica* adults attracted to five Maize varieties through different periods under free choice condition at 35± 1 ºC and 60 ± 5% RH.

Period	Single cross 178 (S.C. 178)	Single cross 10 (S. C. 10)	Single cross 132 (S.C.132)	Single cross 173 (S.C. 173)	Three ways cross 324 (T.W.C.324)
24 hours	12.80 ± 0.37 Ab	16.40 ± 0.75 Aa	8.80 ± 0.37 Bd	10.80 ± 0.37 Bc	7.40 ± 0.40 Cd
48 hours	13.40 ± 0.60 Aab	14.60 ± 0.24 Ba	11.80 ± 0.66 Ab	13.40 ± 0.51 Aab	9.80 ± 0.58 Bc
72 hours	11.60 ± 0.51 Aa	12.20 ± 0.58 Ca	9.00± 0.55 Bb	12.80 ± 0.37 Aa	11.60 ± 0.51 Aa

Means followed by the different capital letters in a column or those followed by different small letters in a row are significantly different at 5% probability level. (Duncan's Multiple Range Test).

Data presented in Table (3) demonstrated the first-generation progeny and weight loss because of the free choice test for the lesser grain borer. The results showed that the variety S.C. 173 had the highest progeny (20.20 ± 0.86 individuals), followed by T.W.C. 324 (19.20 ± 0.97 individuals), and the S.C.132 variety had the lowest progeny in the first generation. (11.40 ± 0.93 individuals). The weight loss was the highest in the variety (S.C. 10) by 0.29 ± 0.02 g, and the lowest weight loss in the variety (S.C. 132) was 0.20 ± 0.01g.

The findings of these work indicates that the insect progeny varied on different maize varieties and these findings are in agreement with El-Syrafi (2005).

Table 3. Mean number±SE of F1 progeny produced and grain weight loss by *R.dominica* on five maize varieties in free-choice test.

Varieties	F1	Weight loss
S. C. 178	17.20 ± 0.80 b	0.22 ± 0.01 b
S.C. 10	17.60 ± 0.93 ab	0.29 ± 0.02 a
S.C. 132	11.40 ± 0.93 c	0.20 ± 0.01 b
S.C. 173	20.20 ± 0.86 a	0.25 ± 0.02 ab
T.W. C324	19.20 ± 0.97 ab	0.25 ± 0.01 ab

Mean ± SE followed by the different letters in a column are significantly different at 5% level of probability (Duncan's Multiple Range Test).

The chemical composition of five varieties of maize is given in Table (4). It can be noticed that *R. dominica* had the shortest developmental period, the highest progeny production, the highest percentage of weight loss, and a highly susceptibility index by the two generation progenies on S.C.10 variety. Chemical composition analysis supported these findings as low percentages of protein (9.89%), fibers (3.06%), total carbohydrates (71.36%); high content of calcium (22.48 mg.100g^{-1}), zinc (5.83 mg.100g^{-1}), iron (3.31 mg.100g^{-1}), ash (1.48 mg.100g^{-1}); and a low amount of magnesium (44.57 mg.100g^{-1}) has been estimated in S.C.10 variety. In contrast, the S.C.178 was the most resistant variety with the lowest susceptibility index and longest development period. This was probably because S.C. 178 contained a high percentage of protein (10.15%), a low percentage of total carbohydrates (70.58%), and a low of moisture (10.55%).

There are differences between the studied varieties in the nutritional content provided by grains of different varieties to the stages of insects, which affects the speed of growth and the number of insects and their success in getting out of the pupal stage, and this is consistent with the results of Bhatia and Gupta (1969).

Table 4. Chemical composition analysis outputs of five maize varieties

Varieties Components	Single cross 178 (S.C. 178)	Single cross 10 (S. C. 10)	Single cross 132 (S.C.132)	Single cross 173 (S.C. 173)	Three ways cross324 (T.W.C.324)
Protein %	10.15	9.89	9.26	8.73	9.36
Total Carbohydrates%	70.58	71.36	68.43	71.20	72.90
Fat%	3.50	3.17	3.88	2.63	1.99
Moisture%	10.55	10.66	14.32	12.06	10.94
Fibers%	2.66	3.06	1.91	3.27	2.81
Ash%	1.92	1.84	2.20	2.10	2.02
	Elements ($mg.100g^{-1}$)				
K	270.35	274 .19	276.25	251.65	270.25
P	280.43	275.79	276.84	278.31	280.56
Mg	46.05	44.57	46.48	46.24	45.50
Ca	22.42	22.48	22.50	22.11	22.15
Zn	5.85	5.83	5.35	5.75	5.78
Fe	3.26	3.31	3.09	3.04	3.37
Phenol	170.73	171.85	173.54	172.30	170.84
Oil	3.94	3.81	4.19	4.19	3.45

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تأثير أصناف الذرة على بعض الخصائص البيولوجية لثاقبة الحبوب الصغرى *Rhyzopertha dominica* (Fab.) (Bostrichidae: Coleoptera).

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قسم الحشرات الاقتصادية – كلية الزراعة – جامعة المنصورة.

الملخص

أجريت التجارب بمعمل الحشرات التابع لقسم الحشرات الاقتصادية بكلية الزراعة جامعة المنصورة. وباستخدام تصميم كامل العشوائية تم عمل اختبار غير اختياري وذلك لتقدير فترة نمو والذرية والفقد في الوزن وكذلك الحساسية لأصناف الذرة المدروسة اتجاه ثاقبة الحبوب الصغرى. بالإضافة الى عمل اختبار الاختيار الحر لتقييم جاذبية كل صنف لثاقبة الحبوب الصغرى وتم عمل تحليل كيماوي لهذه الأصناف لتقدير أكثر المكونات الكيماوية تأثيرا على حساسية الأصناف لثاقبة الحبوب الصغرى. أشارت نتائج هذا العمل إلى أن الصنف هجين فردي 132 (S.C. 132) كان الأطول في فترة النمو (29.4 ± 0.04) يوم. وكان أقل ذرية في الجيلين الأول والثاني (19.4 ± 1.21 و33.2 ± 0.58 فردًا على التوالي)، وأيضًا أقل خسارة للوزن في الجيلين (0.33 ± 0.03 و0.45 ± 0.02 جرامًا). وجد أيضًا أن الصنف هجين ثلاثي 324 (T.W.C 324) هو الصنف الأقل جاذبية لثاقبة الحبوب الصغرى وأن المواد التالية كانت أكثر تأثيرا في حساسية الصنف لثاقبة الحبوب الصغرى: البروتين والأليف والكربوهيدرات والكالسيوم، والزنك ورماد الحديد والمغنيسيوم. أظهرت نتائج البحث وجود تأثير معنوي للصنف المخزن من الذرة وتكوينه الكيميائي على حساسيته لثاقبة الحبوب الصغرى.